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ABSTRACT

An analysis of the historical roots of educational technology is followed by discussions of concerns for instructional design and media selection, systematic approaches to instruction, and the future uses of technology for the delivery of instruction and information. The development and growth of the field are explored, future applications of advanced technologies are proposed, and the need for more refined theories of information processing in describing how people learn is pointed out. This paper includes definitions of educational technology, as well as discussions of the use of media in delivering instruction, various uses of computers in education, and the development of new products that will impact on the field. Problems facing educational technologists are reviewed, and additional research to identify individual characteristics that influence learning is recommended. (RAO)

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AN ASSESSMENT OF THE CURRENT STATUS
OF EDUCATIONAL TECHNOLOGY

by

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INTRODUCTION

One of the primary difficulties in assessing the state-of-the-art of educational technology is to arrive at an acceptable definition or to draw some precise boundaries so that its status may be examined with greater accuracy. Certainly the past years have generated a motley array of statements and definitions concerning educational technology. This author has discussed elsewhere two prevailing conceptions of educational technology (the physical-science-media and the behavioral-science concepts), two viewpoints which are often antagonistic, but can be complementary as well (see Saettler, 1968). The dominant traditional or media concept of educational technology has been manifested in the empirical findings which have consistently shown "no significant differences" in improved learning when experimental comparisons of different treatments, such as film vs. print vs. live teachers, etc., were made. Although over half a century of both theoretical and applied research has produced these results, there is widespread sentiment that "technology can make education more productive, individual and powerful, make learning more immediate; give instruction a more scientific basis, and make access to education more equal" (Report to the President by the Commission on Instructional Technology, 1970, p. 7). Yet, media research to date forces us to the conclusion that we know neither how to measure the psychological effects of media nor how to adapt them to the goals and functions of education.

The alternative behavioral science conception of educational technology is not tied to particular media or devices, but rather to a broader conception of the educational process. In this sense, educational technology is viewed as a systematic development process or as a design science of instruction rather than a product form. For Glaser, educational technology is synonymous with "instructional design" (Glaser, 1968); for Ely, it is a branch of educational theory and practice concerned "primarily with the design and use of messages which control the learning process" (Ely, 1968, p. 4). Gagne sees it as "the development of a set of systematic techniques, and accompanying practical knowledge, for designing, testing and operating schools" (Gagne, 1968, p. 6). Mitchell views it as "the intentional and systematic organization of ideas, activities, and men's physical, social or psychological environment to accomplish a specified and potentially reproducible educational outcome" (Mitchell, 1971, p. 483). This writer's own definition is that educational technology is the systematic application of the knowledge of the behavioral sciences or other relevant knowledge (i.e., insights and implications flowing from the humanities and/or the arts) to the problems of learning and instruction.

This paper is divided into six sections. The first explores the historical roots of educational technology. The second summarizes the status of instructional design and media selection. The third discusses systems approaches to instruction. The fourth describes specific media technologies for instructional uses. The fifth reviews problems of educational technology, and the sixth looks at prospects of educational technology for the remainder of this century.

HISTORICAL ROOTS

The historical roots of educational technology constitute two major clusters. One cluster lies in educational thought and practice of past centuries; the other cluster lies in the developing behavioral sciences.

Educational technology is basically the product of a great historical stream consisting of trial and error, long practice and imitation, and sporadic manifestations of great individual creativity and persuasion. Most important changes in educational aims and instructional practices can be attributed to particular social, political, and economic influences. For example, the transformation of Athens in the fifth century B. C. from an agricultural society into the leading maritime power brought with it a great expansion of trade, a new class of wealthy merchants, and a new attitude toward government. These changes led to a demand for an education that would prepare young men to practice business and politics, a demand soon met by the Elder Sophists, who taught what they called "the art of living." They can be considered the true ancestors of modern educational technology because they laid the groundwork for the first prototype of educational technology by their systematic analysis of subject-matter and by design and organization of instructional materials. They were also well acquainted with the problems associated with human perception, motivation, individual differences, and evaluation. They also realized that different instructional strategies were required for various behavioral outcomes. What is particularly significant is that they viewed technology or techne as the practical art of using knowledge to solve problems of learning and instruction.

Throughout the centuries, many educators have made important contributions to the growth and development of educational technology. For example, the growth of knowledge in the seventeenth century led Johann Comenius (1590-1670) to envision a system of instruction whereby learners could be led inductively to generalized knowledge by working with natural objects and studying practical things.

Before the nineteenth century, instruction was essentially that of strict recitation of matters learned entirely by rote. This was in accord with the dominant theory that children were innately evil and that their natures had to be broken and brought into complete subjection. However, there were forerunners of contemporary educational technology whose theories and concepts were far ahead of prevailing educational practices of the time. Such men as John Locke (1632-1704), Johann Pestalozzi (1746-1827), Frederick Froebel (1782-1852), and Johann Herbart (1776-1841) viewed instruction in more systematic terms and cognitive elements came into central focus in the instructional process.

In the early years of this century, American educators looked to the development of a science of instruction. Edward Thorndike (1874-1949) was the exemplar of what could be done by empirical-inductive means. John Dewey (1859-1952) also rose to eminence during this period and contributed to educational technology through his conception of instruction in terms of scientific method (see How We Think, 1910). The coming of the machine age and the realization that all who went to school could not enter white-collar jobs stimulated the growing demand for more practical curricula and more functional methodologies. Evolving slowly were ideas on how best to use new media, such as the

museum exhibit, the photograph, the projected still picture, and the motion picture, in instruction.

It took time to bring about widespread changes in content and methodology. In the early decades of this century, small groups of educators in the United States formed associations which featured the words "visual instruction" or "visual education," stressing the pictorial content as opposed to the verbal emphasis of lectures and books. An early abstract-concrete continuum designed to serve as a guide to instruction appeared in Exposition and Illustration in Teaching, written in 1910 by John Adams. However, such concepts as these, followed later by others (i.e., Joseph Weber and Edgar Dale) seem to have been introduced more as post hoc rationalizations for visual instruction (later called audiovisual instruction) than as a direct influence on the design and development of instructional materials. It is clear, for example, that the development of motion pictures and television occurred almost entirely without reference to education or learning theory. Historically, "audiovisual materials" have been used primarily for group or mass presentation without explicit regard to individual differences in learning ability. Traditionally, the roles of instructional films have been seen as aids to teaching rather than as self-contained sequences of instruction.

One factor which characterized general overall thinking about the use of media in the early decades of this century was specialization in the production and administration of instructional media. At the outset, following the turn of the century, commercial interests producing media for school purposes centered on one or two media. Certain companies made blackboards, others produced slides, some produced

motion pictures, others concentrated on maps and models, one centered on sets of slides and stereographs, others produced slidefilms, and some specialized in recordings.

Parallel with specialization by producers of media there was specialization in the administration of instructional media. For example, New York State's Division of Visual Education collected and distributed lantern slides only. The St. Louis Educational Museum concentrated on exhibits. The University of California's Department of Visual Education in University Extension distributed motion pictures only. In a number of universities, the department of visual instruction was in charge of the distribution of motion pictures and another department was charged with education by radio. At one point during the 1930's, there was a national association of "visual educationists," a national association of educators specializing in school excursions, and a national association of those in charge of education by radio. As time went on, there were those who administered "audiovisual materials" under one central unit and who tried to develop a rationale for the value and place of each medium or device in instruction.

Development of a Behavioral Science Conception of Educational Technology

The relationship between the behavioral sciences and educational technology was somewhat tenuous during the early years of this century, but connections have taken a firmer hold in recent years. As we have seen, Edward Thorndike was the precursor of the modern behavioral science concept of educational technology. Thorndike influenced the work of W. W. Charters, Douglas Waples, and Franklin Bobbitt, men who

laid much of the groundwork for a behavioral science technology of instruction. Another important early development which brought about a closer relationship between educational technology and the behavioral sciences was the emergence of programmed instruction in the early years of this century. Although Sidney L. Pressey is usually given credit for pioneering the programmed instruction movement, it was actually Maria Montessori who devised the first self-correcting devices as early as 1912. By the middle of the century, programmed instruction was reconsidered and revised in the work of Crowder (1960) and Skinner (1968).

Another important influence on the development of a behavioral science educational technology came from the cybernetics tradition. Shortly before and during World War II, it became increasingly apparent that the exploration of control problems in devices held a particular significance for the development of man-machine systems. The application of cybernetic principles to instruction was first systematically developed by Gordon Pask with the introduction of his so-called adaptive teaching systems in England in 1953 (Lewis and Pask, 1966). This was the first of many steps toward a computer-assisted instruction (CAI). Still another influence on educational technology from cybernetics is gaming and simulation.

By the 1970's, the trend is away from a machine, thing-object orientation to a technology of instruction rooted in cybernetics and systems analysis, instructional design and behavioral engineering, as well as decision theory, simulation, and operational research. Today the dominant term has become either instructional or educational technology despite the fact that some still resist this concept and

feel that the words "communication and learning or learning resources" should be included. At the present time, a kind of compromise has been reached and the professional organization of the field in the United States has come to be known as the Association for Educational Communications and Technology.

INSTRUCTIONAL DESIGN AND MEDIA SELECTION

It seems clear on the basis of research that no single medium is superior in all respects in any instructional situation, but it is also apparent that any medium can make a viable contribution to almost any learning task (Schramm, 1977). Nevertheless, present research can offer only limited or incomplete guidance to the instructional designer in the selection and use of media for instruction. This need has been evident for a long time, and even now, there is hardly an adequate solution to the problem. At a more theoretical level, both educational and psychological research has been seriously hampered by the absence of a theory of the structure of the symbol systems that constitute such an important part of our environment, the media that transmit these symbols, and the cognitive transformations that take place in those exposed to them. Research on media, without this framework, has reflected this limitation (see Allen, 1971).

Some time ago, this author stated that "an urgent need exists for a taxonomy of instructional media which can provide a systematic approach to the selection and uses of media for educational purposes" (Saettler, 1968b). Since this time, important work has been done, but

the need still exists. After reviewing the research in the hope of finding some source of help on this matter, Campeau summed up her conclusions as follows:

In brief, an extensive literature search was for research evidence relevant to selecting appropriate media for specified learning tasks. In particular, it was hoped that results of studies on the instructional effectiveness of media under a variety of learner and treatment conditions could be applied to the task of attempting to construct a media taxonomy. The disappointing result of the literature search was that little more than a dozen experimental studies were found to meet criteria that gave them some assurance that findings were interpretable.

What is most impressive about this formidable body of literature surveyed for this review is that it shows that instructional media are being used extensively, under many diverse conditions, and that enormous amounts of money are being spent for the installation of very expensive equipment. All indications are that decisions as to which audiovisual devices to purchase, install, and use have been based on administrative and organizational requirements, and on considerations of cost, availability, and user preference, not on evidence of instructional effectiveness--and no wonder. To date, media research in post-school education has not provided decision makers with practical, valid, dependable guidelines for making these choices on the basis of instructional effectiveness. (Campeau, 1974, p. 31)

Commenting further in this same report, Campeau writes:

The question of which media to compare, or which learner and media characteristics to examine should be determined in the light of subject matter and task characteristics. At present, an entire unit or course is programmed, or produced as a series of televised lessons, or filmed, or tape recorded, or produced in multimedia format, without identifying specific instructional objectives to be met and without analyzing the types and conditions of learning required. Learners are assigned to these experimental treatments without regard for traits that might interact with media and task characteristics. (pp. 33-34)

It is clear from the Campeau study that a comprehensive analysis is required of the types of learning tasks and instructional events that make up teaching as well as an analysis of the media of instruction so that their characteristics and the ways of using them can be incorporated into a design that includes the total learning situation. Moreover, such an analysis must include data concerning individual

differences and the classification of different learning conditions.

Toward Guidelines for the Design of Instruction

Gagne's The Conditions of Learning (1965) led the way toward bringing a stronger connection between learning theory and the design of instruction. Other notable attempts have been in recent years to provide a guide to instructional design and media selection. Briggs wrote a monograph (in collaboration with Gagne and others), Instructional Media: A Procedure for the Design of Multimedia Instruction (1966), which deals with the planning and developing of instruction and particularly with media. He wrote a second book, the Handbook of Procedures for the Design of Instruction (1970), for the design of instruction and the selection of media. In 1974, Gagne and Briggs wrote their Principles of Instructional Design. Still another approach was made by D. T. Tosti and J. R. Ball (1969) through the development of a media classification model.

Unfortunately, the present state of the art does not solve the persistent problem of instructional design and media selection. As Heidt (1978) says, "Most classification systems claim to be applicable to the solution of practical problems of media design and instruction. Such pretensions, however, prove to be illusory as soon as a media designer or teacher attempts to use them for one of his everyday problems" (pp. 37-38). Heidt says further:

The criterion of categorization is too general or too complex, so that the classification results only in trivial statements, as for example in Gagne's table where all media are said to be suitable for the presentation of the instructional stimulus, either with or without limitations.

It is difficult to realize the instructional relevance of the principle of arrangement chosen. What would be the instructional consequences if we could detect that two media under discussion differ with respect to the quantity of sensory cues they provide?

The concept of medium is too complex and too wide. What, for example, does Gagne mean by 'teaching machine'? The differences between the devices covered by that term are immense. Or what does Briggs mean by 'TV'? To what form of organization (public broadcast, CCTV, etc.) and to what aspect (transmission, video-tape production, etc.) do his statements refer?

The matching of media with the respective categories by means of ratings like 'yes-limited-no' is too comprehensive and too general, and often incomprehensible without further information. What help is it for a teacher to learn that he may use sound movies in nearly all instructional situations as Briggs suggests? Why are printed media supposed to be suitable for directing attention while moving pictures are said to be unsuitable? On such a general level it is possible to give quite a number of good reasons for a reverse rating. (1978, p. 38)

The development of differential learning psychology has developed in recent years and has resulted in a particular learning research known as "aptitude-treatment interaction" (ATI) or "trait-treatment interaction" (TTI) research, which considers the connections between personality traits of the learner and variables of the instructional situation. Consequently, the introduction of modern media into instruction and learning has offered an opportunity to take into account the treatment of instructional design and media as part of the learning environment. Allen (1975) reviewed research concerning aptitude-treatment-interaction and, simultaneously, developed an extensive list of generalizations that instructional designers might use. When Allen looked at the research evidence itself, he said:

There is little definitive evidence from the aptitude treatment interaction research that points conclusively to the employment of practices that might guide the selection of the more general instructional strategies, much less lead to the design of specific instructional media. The research results are so fragmentary and diverse that generalizations from these alone are virtually impossible...

We must look beyond the experimental data and base our decisions also on theories about how individuals learn and process information and upon the apparent directions suggested by the findings...

The translation of research and theory into real-life applications is desperately needed. (p. 139)

A provocative approach to instructional design and media use has been offered by Salomon (1974). According to Salomon, "The better a symbol system conveys the critical features of an idea or event, the more appropriate it is" (p. 392). Therefore, in choosing a medium of instruction, one analyzes what is to be taught, then searches for the symbolic coding system and the method of presentation that best fits the key elements of the information to be transmitted. Thus, "if the simultaneous operation of valves in an engine is taken as the critical feature, language would not be the appropriate medium to convey that sort of information" (p. 392). Salomon makes the point that "since the requirements of task and the effects of media differ, there can be no best technique, method, or medium for the attainment of a general educational objective" (p. 395). Thus, "the search for the 'best' mode of presentation for such general goals is therefore bound to fail, as indeed it has failed in the past" (p. 395).

Bloom (1956) and numerous educators and psychologists have contributed to the development of a taxonomy of educational objectives. Three domains have been considered: cognitive, affective, and psychomotor. Discussions of these three domains and related taxonomies are available from a variety of original and secondary sources (see, for example, Brooks and Friedrich, 1973; Kibler, Barker, and Miles, 1970). Although the objectives were originally written in general terms, some writers (e.g., Magar, 1962; Vargas, 1972) have explained how to make

them behavioral. Probably the most significant research implication concerns the use of behavioral objectives as a specific message design so as to cue the learner to attend to relevant information (e.g., Kaplan and Rothkopf, 1974; Kaplan and Simmons, 1974). Jean Piaget's approach, which focuses on both the psychomotor and cognitive domains, has several implications for the instructional designer. Sigel (1969) notes that teachers should adapt to the developmental changes of learners, construct curricula based on developmental sequences, and provide the learner with multiple experiences to facilitate learning. It is also important for young learners to experience their environment through physical manipulation.

Researchers have not to this time characterized instructional tasks and medium potentials precisely enough to reach any definitive conclusions about which medium is better suited to which educational objective. In recent years, Olson and Bruner (1974) and Lesser (1974) have sought to characterize media-specific capabilities. None of these efforts have been supported by very much experimental evidence. As Schramm (1977) concluded after a comprehensive review of the research, instructional media may be equally useful for most educational tasks. However, the quality of media research is probably the real issue. It appears likely that more quality research will be conducted in the next decades for the purpose of determining the total effects of a given medium or combination of media in particular learning situations. Probably the crucial question will focus on the question of whether or not individual learners process information more effectively via print, visual or audio media. Moreover, it is clear that educational technology can no longer afford to remain isolated from the fields of developmental psychology, differential psychology, and neuropsychology (Hittrock, 1978).

SYSTEMS APPROACHES TO INSTRUCTION

One of the most significant advances in educational technology in recent years has been the development of systems approaches to instruction. During the 1950's and 1960's educational technology became increasingly focused on language laboratories, teaching machines and programmed instruction, multimedia presentations, and the use of the computer in teaching. Out of this development came a systems approach, or an effort to design a complete program or develop a course of instruction to meet specific needs and objectives. This movement obviously paralleled the military and business worlds, but the procedures were similar. Instructional goals and objectives were precisely defined, the various alternatives were analyzed, the instructional resources were identified and/or developed, a plan of action was devised, and the results were continuously evaluated for possible modification of the program.

Many instructional systems approaches or instructional designs have evolved with their various flow charts and lists of steps to be followed. One of the clearest models was developed in the early 1970's (see Kemp, 1971). Banathy (1968), Corrigan (1969), and Gagne (1966) have designed specific strategies for instructional systems. A more recent system derived from the operant conditioning approach is the Personalized System of Instruction by Keller and Sherman (1974). This approach is characterized by the following features: self-pacing, mastery of content, emphasis on written materials, the use of peer-proctors, and the use of lectures as motivational devices. Loughary (1968) has commented: "Without carefully defined objectives, the use

of the systems approach is likely to be educational nonsense" (p. 730). Thus the systems approach is a way of thinking and is as useful as the validity of the data fed into the process. Designing precise, and measurable objectives is one of the most-definitive and important tasks of the systems approach.

A focus on the design of entire instructional systems provides a clear distinction of educational technology in contrast to traditional instructional approaches. Gibson (1971) describes this approach as:

the systematic application of people, ideas, materials, and equipment to the solution of educational problems. The process by which the learning materials are selected or produced, by which the modes of communication are designed, and arranged in the learning environment, and the strategies by which human and non-human resources are utilized to improve the efficiency and effectiveness of education is educational technology. Thus we are concerned with the application of the systems approach to the more scientific and precise solution, use, and evaluation of resources for the improved design of learning experience. Further the entire school plant and community are integral, vital parts. (pp. 1-2)

Educational technology not only includes problems of instructional design and management of learning, but must also involve development and management of diverse educational systems where instruction and learning can take place.

Conceptual Contributions to Systems Approaches

There are, at present, distinct discipline areas which contribute conceptually and methodologically to systems approaches. These are General Systems Theory, cybernetics and the resulting management information and control devices and techniques (i.e., program evaluation and review technique (PERT), and GANTT charts, critical path method (CPM), cost benefit analysis, simulation techniques, and operations

research strategies), and psychosocial systems which purport to study man's psychological state (system) as a function or product of a variety of interrelationships.

Behavior Systems: A New Direction in Educational Technology

Behavior systems in education range from the "minisystem" of programmed instruction to complex macrosystems encompassing an entire school. According to Zifferblatt (1973), a behavior system model should (a) have the capability of representing all interrelationships between different contingencies (e.g., reading, math, social behavior); (b) specify all operations (contingency arrangements) required to generate and maintain behavior (e.g., time, media, teacher behavior, cost); and (c) describe the progress of flow of activities in conducting the program (p. 335).

Behavior systems evaluation is focused on accomplishment of the mission and is primarily concerned with how system priorities can be made more efficient and effective; or, specifically, what is happening in a particular program, how can this be represented (interrelationships), and how can operations be continually refined while holding the program constant? Operations research or management science provides a useful and important tool for analyzing complex instructional systems and can also be an excellent guide for the design of instructional systems.

Humanizing the Systems Approach to Instruction

A systems approach is a tool for decision making which enables those who manage the system to state their bias in the form of a goal,

and to operate the system so that performance will achieve a particular goal. Frequently, the system is viewed as being inhumane or impersonal, but if the purpose of the system is to promote humane interests, the resulting outcome should be an effective and efficient humanized system. It appears obvious that systems can be either inhumane and depersonalized or personalized and humane. They are whatever they were designed to be.

Programmed and Computer-Assisted Instruction

Conceptually and methodologically, programmed instruction and computer-assisted instruction can be viewed as minisystems. (See Ofiesh and Meirhenry (1964) as a major source of information on systems applications in programmed instruction.) In the early 1960's, definitions of programmed instruction usually described various formats, such as small frames, requirements for responses, and the like. Markle (1967) pointed out that such definitions restricted the class of instructional materials that could be called programs. She, instead, defined an instructional program as a "reproducible sequence of instructional events designed to produce a measurable and consistent effect on the behavior of each and every acceptable student" (p. 104). This definition has received general acceptance and the term "programmed instruction" has come to be widely accepted as "validated instruction" or is considered to be a systematic development process in which the developer or instructional designer assumes complete responsibility for student learning.

Computer-assisted instruction (CAI) has been defined in many ways through the years. One definition defines CAI as "an interaction

between a student, a computer controlled display, and a response-entry device for the purpose of achieving educational outcomes" (Bunderson and Faust, 1976, p: 47). Without question, CAI offers a new science and technology of instruction whose potential has hardly been probed. Perhaps it will some day constitute the main thrust of a behavioral science oriented educational technology.

The programmed instruction movement reached its peak during the early 1960's. Unfortunately, the claims of programmers far exceeded their skill and school storehouses began to be filled with unused teaching machines and programs. By the late 1960's and early 1970's, publishers had drastically retrenched and there came to be a realization that effective programmed instruction must involve a systematic and empirical development process. Meanwhile, the middle 1960's marked the beginning of the boom in CAI. Again, as in the beginning of the programmed instruction movement, computer companies were merging with publishing companies and there were great expectations for profits in the educational market. Federal aid for research and development provided most of the impetus for CAI and many projects were begun. By the early 1970's, federal funding had begun to diminish, and the new educational market had not materialized. Computer companies and publishers began to withdraw from the field and a new decline set in. Again, mistakes of the programmed instruction movement had been repeated because CAI's complexities of hardware, software, and courseware as well as cost involved had not been sufficiently understood.

A number of notable CAI programs have been developed in recent years. One of the earliest, the PLATO project, first begun at the University of Illinois in 1959, has been described elsewhere and need

not be repeated here. It is important to note that PLATO has had a great influence on CAI development because it shared ideas and materials, conducted research, and provided a training ground for the next generation of CAI developers and users. In 1971, the TICCIT (Time-shared Interactive Computer-Controlled Information Television) Project was funded by the National Science Foundation (NSF) as a major demonstration project to develop, test, and demonstrate a minicomputer-based CAI system supporting 128 color television display terminals and delivering courses in freshman and remedial mathematics and English composition in two community colleges.

Various sequencing strategies have been devised in CAI. Atkinson (1972) has described four criteria which must be met in his approach to a theory of instruction: (a) a model of the learning process must exist; (b) admissible instructional actions must be specified; (c) instructional objectives must be specified; and (d) a measurement scale must exist that permits costs to be assigned to each of the instructional actions, and values of payoffs to the achievement of each overall objective (pp. 921-31).

In recent years, Gordon Pask in Great Britain has developed an instructional approach to CAI which is radically different from the procedures of Atkinson. Pask's procedure is based on a comprehensive cybernetic theory which involves a conversation between two or more participants on a series of topics that form a conversational domain. One participant is the subject; the other may be a machine or a person serving in the role of the experimenter's agent. Because of the complexity of this cybernetic learning environment, it usually involves some type of complex electronic equipment. Pask's work is still not

well understood in this country, but it appears likely that it may have significant influence on future approaches to instructional design as well as providing a theoretical framework for those working on artificial intelligence (AI) systems for CAI.

It is likely that the greatest progress in educational technology in the near future will be seen in the development of CAI systems. As increasingly more sophisticated instructional CAI systems are developed, it does not seem overly optimistic to predict that a historical breakthrough will be made in the design and development of highly individualized systems. These systems will be capable of diagnosing individual differences, providing for continuous feedback for the revision and improvement of programs as well as providing for self-pacing, practice, and conversational procedures between learner and programmer involving problem solving situations. Moreover, future systems promise day-to-day instructional design possibilities which would allow teachers to become instructional developers for computers without the necessity of learning computer programming. Just as solid state technology has made calculators widely available, so the micro-computer revolution promises to make CAI terminals readily accessible in homes, schools, and learning centers.

MEDIA TECHNOLOGIES FOR INSTRUCTION

The impact of media technologies on the extension of instructional possibilities has been immense in recent years. One important developmental process is reflected in the emergence of simpler, more practical video recorders, cassettes and discs, and low cost television equipment.

New media technologies for the future point in the direction of both macro and micro technologies. At the macro level, where broadcasting was once confined to terrestrial transmission, the development of communications satellite technology has made Marshall McLuhan's "global village" a reality. Also, as an alternative to open broadcasting, "broadband communications" or cable systems involving direct video and audio signals have important implications for educational broadcasting. At the micro level, an increasing miniaturization of equipment, or what has been called "microelectronics" has meant that media can be used more extensively. Micro technologies include such developments as the portapak video camera, the videocassette, and electronic films. As distinguished from photographic film, electronic films are delicate masses of electronically active material condensed, for the most part, from hot vapors onto cold, hard insulating surfaces such as glass. Depending on the materials used, such films, called either thin or thick, are often ten times thinner than an ordinary soap bubble. These films may eventually lead to a television camera only half an inch square, a hand-held battery-operated computer, a form of computer that could store a quarter million bits of information on a glass slide half a foot square, a new type of video tape which could store pictures optically for later readout by an electron beam, and a revolutionary type of integrated circuitry for application in all forms of electronic equipment.

The application of the media technologies for instruction occurred in a number of ways during the past decade. One of the notable applications in the industrialized world was that of the Open University in Great Britain. This broadcasting system, involving multimedia combinations of radio, television, films, and programmed materials,

began in 1971. Foundation courses, created by course teams of both media and academic specialists, were directed to over fifty thousand students throughout England. A similar approach was made by "Project Sun" in Nebraska where the multimedia mix involved television, audio cassettes, newspapers, learning kits, and learning resource centers.

The development of telecommunications satellite systems brought about some interesting educational experiments. The first were in audio, involving health education in Alaska, i.e., the PEACESAT (Pan-Pacific Education and Communications Experiments by Satellite) System. The U. S. Office of Education has conducted its experiments on ATS-1 and ATS-3 satellites, utilizing not only the PEACESAT ground stations, but those in Alaska and Appalachia as well.

ATS-6, launched in May 1974, broadcast for a period of nine months to more than fifty rural schools in an eight-state area in the Rocky Mountains. Programming emphasized career, education, and social and environmental studies. Later, this same satellite was moved to India where it contributed to the Indian Satellite Instructional Television Experiment (SITE). Programs were produced under the control of All India Radio and were beamed for four hours a day (using one video and two audio channels) to 2,400 villages in six states. Meanwhile, the newest available experimental communications satellite is a joint U. S.-Canadian venture, the Communications Technology Satellite (CTS). Like ATS-6, it is designed to explore the technological configuration of a high power satellite working with small and relatively inexpensive ground stations.

At present, there are four operating commercial domestic satellite systems in the United States: those of Western Union, RCA, American Communications, and Comsat General. Of particular interest to educational

broadcasters is the fact that public broadcasting has contracted with Western Union to replace the terrestrial interconnection for public television, supplied in the past by the telephone company, with interconnection for the affiliates of National Public Radio to be added in 1980.

In terms of the future applications of satellites for educational purposes, it can be stated with some assurance that future developments will intensify and expand in this field. Additional experimental communications satellites are in the talking and planning stage. One of the most significant implications of the National Institute of Education funding of satellite experiments may be the impetus it can provide for future experimentation and development.

Communications satellites used for broadcasting as well as telephony unquestionably present opportunities unparalleled by more traditional media technologies, but they lack the kind of interactive communication which the traditional media do provide. For example, the use of posters, filmstrips, films, maps, charts, etc., may more effectively meet such needs as mobility and low cost. The potentials of radio, with its easy accessibility, relatively low cost, and its possibilities for two-way interactive communication have not been fully realized in the industrialized nations. In contrast, too much attention tends to focus on such big, prestigious media as television, computers, and satellites. Neither so-called "big media" or "little media" are necessarily better or more effective in instructional situations. It is clear, however, that the increasing diversity and development of media technologies will require serious decisions about a rapidly expanding range of strategic alternatives that will be appropriate for specific educational objectives.

PROBLEMS OF EDUCATIONAL TECHNOLOGY

The potential of educational technology is revolutionary, but this potential is not likely to be realized in any reasonable time unless a number of serious problems are solved. These problems involve public policy issues, technical strategies, research and evaluation, as well as the problems associated with the development of a behavioral science oriented educational technology.

An integrated approach to educational planning and research is needed. The great advances of media technologies and their rapid expansion in recent decades calls for a new type of research typified by the works of Elihu Katz (1977), Katz and Wedell (1977), Parker and Mohammadi (1977), and Anthony Oettinger (1977). An integrated approach to the problems of educational policy and planning would have to focus on message content, intent, production, distribution, and evaluation. Also, since most media research in the United States has followed the Shannon-Lasswell paradigm of the communication process called "S-M-C-R-E" (a Source (S) sends a message (M), via certain channels (C), to the receiver (R), who responds or reacts to this stimulus with an effect (E)), it is time that media researchers adopt new, more fruitful paradigms. The prevailing model assumes a mechanistic and atomistic approach to the communication process and focuses on the effects of the source, message, or the channel on change in knowledge, attitude, and overt behavior of the receiver--as if he or she were passive and lived in social isolation. Therefore, some researchers have reversed the question of media effects to ask, rather, what uses and gratifications the receiver brings to the media. Katz (1977) has described this media research trend as follows:

They are examining (Singer, 1976; and Bruner and Olson, 1973), together with brain specialists (Blakemore, 1977), how information is processed, and more specifically, what physical and psychological functions are activated by different kinds of media (pictures, spoken words, music, print). Is such information stored differently, and under what circumstance is it recalled? What sorts of information are most compatible with which of the media? Are some people specialized in processing one or another sort of information? How well do different media combine? Is there a learning process involved in dealing with a particular medium (Salomon, 1972) and if so, is it also applied to other situations?... Gratification studies in Israel and Australia (Katz and Gurevitch, 1976; Kippax and Murray, 1976) have found that books are thought to cultivate the inner self; films and television to give pleasure; and newspapers, more than other media, to give feeling of efficacy and stability. Radio is high on companionship... Television performs more different functions than any of the media, but there is debate over whether its role as agent of information is deemed as important by the audience, as its role as agent of entertainment. (p. 30)

It seems abundantly clear that educational technology cannot reach its full potential until research discovers more about the learning process and how it varies in each individual with different instructional treatments. Although media research shows no significant difference in achievement than control groups taught by a teacher, the findings show, as pointed out by Oettinger and Zapol that:

Learning is largely independent of the details of means, hence ...issues of policy and technology, on the one hand, and of learning method and content, on the other hand are essentially independent. No-significant-difference findings, therefore, leave alternatives to the accepted ways of schooling wide open, alternatives that might, according to public preferences, achieve lesser costs, greater individualization, or some other personal or social benefit without, at the very least, making any difference so far as measurable learning performance is conceived. These benefits are neither all equally attractive to everyone nor unequivocally measurable. Preferences and priorities keep changing. Acceptable strategies for making technology responsive to learning must therefore permit continuing and diverse public choices; decisions about ends and means must be reserved as matters of public policy and not left unattended to experts. The strategic question of how technology affects control over the means of learning must take preference over pedagogical nits to

assure that public preferences--or significant differences, if some are ever found--will be accommodated and not dictated by how technology is deployed. (pp. 6-7)*

One of the basic problems confronting the American educational system is that it is not in fact treated as a system. It has been generally fragmented and broken down into discrete functions. Moreover, educators, for the most part have resisted the ideas of operational research and systems analysis. As a consequence, little or no consideration has been given to the total learning environment. Until all the theories of learning are synthesized and brought together in one system, there is not likely to be an effective way to unify the structure and process of instruction. In addition, any system analysis must take into account the timetable for bringing about instructional plans as well as determining the probable costs. Very little has been done to define what instructional priorities should be established and how educational technology can be implemented to realize these goals. This author is convinced that the most exciting contribution of educational technology in the future will have to be in the area of instructional systems rather than media.

In the years ahead, instructional units will probably be more flexible than they presently are and each unit or instructional system may involve the learner in designing various aspects of the program. While some may view the systems approach as depersonalized and inhuman, it is important to point out that educational technology has the potential of developing a system to be humanizing as well. A systems approach does not de-personalize education unless it is designed for that purpose. The essential problem of educational

*Pages indicated refer to the chapter preprint which is available as ED-064 902.

technology is that it has been restricted to media when the real need is a new conceptualization of instruction as a system.

PROSPECTS

In terms of media technology, the future promises many communications marvels. For example, it is likely that a portable terminal/display "carrel" may be developed whereby the user could have immediate access to practically all of the printed or audio-video information stored anywhere in the world. This electronic carrel would contain a video monitor, a photocopier to instantaneously reproduce any material desired, a fiber-optic laser terminal that would provide potential access to thousands of information channels, and a series of operational modes which could give the learner access to computer-based instructional programs or to instructional materials in every "viewing" or "listening" mode. Meanwhile, the home itself may be transformed into an instructional resource or learning center by means of a television wall screen connected to videotapes, facsimile printers, and minicomputers which can be activated to transmit any type of stored information or instructional program available. By means of two-way communication, the learner will also be able to send messages as well as receive them. A real breakthrough in man-computer communications will come with the development of speech interfaces for computers. Through this capability and the universally available telephone system, as well as radio and cable communications with computers, computer capability will be opened to almost everyone who has access to a telephone. With this development the possibility of

extensive instructional computer networks is likely to materialize in the future.

Speculations about the technical possibilities of the future are relatively easy because most of the hardware components have already been worked out theoretically or in a practical sense. However, the difficult predictions for the future of educational technology focus on the process itself. As we have indicated in the previous section, the real problem of educational technology is that of instructional design. For example, John Goodlad, after a comprehensive study of educational practices in the United States, concluded that:

Many of the changes we have believed to be taking place in schooling have not been getting into classrooms; changes widely recommended for the schools over the past fifteen years were blunted on school and classroom door. Chances are, most teachers seeking to teach inductively, to use a range of instructional media, to individualize instruction, to nongrade or team teach, have never seen any of these things done well, let alone participated in them to the point of getting a "feel" for them or how to proceed on their own. We simply do not have in this country an array of exemplary models displaying alternative modes of schooling, in spite of assumed local control and diversity. (p. 103)

A look into the future sees the realization of a new conceptualization of instruction as a system. However, this development promises to be evolutionary rather than revolutionary. There is an obvious lag between our ability to establish the level of the behavioral change we desire and our ability to determine whether the change has occurred. This problem will have to be solved if a true systems approach is to be developed. Moreover, it has rarely been pointed out or recognized as a problem that information and knowledge are not identical or synonymous as it is frequently assumed. For example, computer information systems are not just objective recording devices. They also reflect concepts, hopes, and attitudes. Thus, the communications

revolution has within it the poison seeds of the past. Instead of creating a "new future," modern communications may mask the underlying forces of politics and power.

It is the particular futuristic bias of this writer that educational technology can generate humanistic experiences. Thus, a system designed specifically for that purpose will synchronize the goals, methods and means and evaluation so as to bring about an effective and humane system. However, unless some basic conceptual, methodological, and political changes occur within the foreseeable future, the glowing expectations for educational technology may not be realized before the end of this century. Let us hope that educational technology in 2001 A.D. will develop into something far more exciting and creative than we now have.

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